CITY OF CAMBRIDGE

PUBLIC WORKS COMMITTEE

REPORT

on the

SEWAGE TREATMENT WORKS

March, 1965.

T. V. BURROWS, M.I.C.E., M.I.Mun.E.,
City Engineer and Surveyor,
Guildhall, Cambridge.

CITY OF CAMBRIDGE

1965

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To: The Chairman and Members of the Public Works Committee.

Mr. Chairman, Ladies and Gentlemen,

In April, 1952 I presented a report on the extensions to the Cambridge Sewage Treatment Works which were required to eliminate the land treatment of sewage and at the same time provide a modern works and pumping station capable of dealing with the increasing flows of sewage from both the City and parts of the Chesterton Rural District. The City Council approved this report but due to financial restrictions obtaining at that time the proposed extensions were phased into three separate stages. Stage I for treating the liquid content of the sewage was completed at the Works in 1958 at a cost of £389,672. Contracts have now been let at a total cost of £380,242 for Stage II which is the new Riverside Pumping Station. Stage III for treating the sludge content of the sewage is reconsidered as part of this report.

When considering extensions to the Works the opportunity has been taken to reassess the trends in population growth, the increased consumption of water and the standard of final effluent required before discharge into the river as well as existing conditions at the Sewage Treatment Works. Meetings have been held with officers of the Chesterton Rural District Council, the Cambridge Water Company and the Great Ouse River Board to discuss these important factors.

In common with most towns and cities particularly in the South East of England, the population in the drainage area and the water consumption have increased at rates greater than envisaged twelve or more years ago, with the result that the sewage works is now receiving and treating the maximum flows for which the extensions completed in 1958 were originally designed to ultimately receive. Urgent steps must therefore be taken now to increase the capacity of the works if a satisfactory final effluent in accordance with the present River Board standard is to be maintained.

This report therefore includes recommendations for additional extensions (Stages IV and V) which will provide a further increase in capacity of the treatment plant dealing with the liquid content of the sewage. These additional stages are necessitated partly by the increased volume of crude sewage being received at the works, and partly because of the far more stringent requirements for the final effluent which the River Board have indicated they will require before it is discharged to the River Cam.

The proposals for the layout of the works and the extensions differ from those proposed in 1952 due to the greater flow of sewage to be treated. An arrangement has been adopted which will permit future extensions to be carried out when occasion arises without interfering with the operation of existing plant.

Greater use of mechanical plant is proposed to make operation of the works possible with a smaller labour force than would otherwise be required, and to improve the working conditions of the staff.

The proposals set out in this report thus comprise:—

Stage III	Sludge treatment plant including sludge digestion equipment and power generation plant.
Stage IV	Additions to various parts of the works to accommodate the increasing flow up to a Dry Weather Flow of 8.5 million gallons per day from a total population of 135,500 persons.
Stage V	Tertiary treatment plant for improving the effluent from the humus tanks to comply with the revised standard of the River Board. (This stage is dealt with in principle only).

The total estimated cost of the extensions to the Sewage Treatment Works as given in the attached report for Stages III, IV and V is £1,120,000. This figure is based on prices ruling at July 1964, when the preliminary design was sufficiently advanced to enable such estimates to be made and "budget prices" obtained from manufacturers of specialist equipment.

It is envisaged that the existing works could be enlarged by further extensions to those now proposed to accommodate a D.W.F. of 10 m.g.d. which on the present basis of design is equivalent to a total population of about 160,000 persons.

When preparing the present proposals regard has been taken of the possibility of the D.W.F. being likely to exceed 10 m.g.d.

In conclusion I should like to record my thanks to those members of my staff (Appendix VIII) who have been engaged on the research and design work involved in the preparation of this Report and the detailed scheme which it covers.

T. V. BURROWS, M.I.C.E., M.I.MUN.E.,
City Engineer and Surveyor.

The Guildhall,
Cambridge.
March 1965.

SEWAGE TREATMENT WORKS

REPORT

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SEWAGE TREATMENT WORKS

A brief history and description of the existing works is given in Appendix I while Appendix II contains definitions of the technical expressions appearing in the report.

NEED FOR EXTENSIONS

(1) There are always inherent difficulties in forecasting population trends and making predictions regarding the volume of sewage likely to result from a given number of people. The need for extensions to the existing sewage treatment works is therefore dealt with in this report in the light of present conditions and those that are likely to arise during the next twenty years. Accordingly a degree of flexibility has been introduced into the design with particular reference to the layout of the works so that variations and additions can be made in the future to meet changing circumstances.

(2) In view of the financial restrictions obtaining in 1952, when the previous report was submitted to the City Council, it was necessary to separate those proposed extensions into three stages. The first stage dealt with the treatment of the liquid content of the crude sewage and this part of the extensions was completed in 1958. Second in order of priority was the construction of a new pumping station at Riverside which is required to effectively deal with the volume of sewage draining to this point and to provide suitable low level connections for the new trunk sewers being constructed in accordance with the Main Drainage Programme. Contracts have been let for this pumping station and work started on site in December 1964.

(3) The third stage of the 1952 proposals was to provide a treatment process for the raw sludge separated from the crude sewage and it was decided to adopt sludge digestion and collect the gas produced by this process to be subsequently used as fuel for power generating equipment.

(4) When raw sludge is dried under atmospheric conditions obnoxious smells are produced which cause great nuisance. The urgency of completing the third stage can be gauged from the many letters received in the Department and those appearing in the *Cambridge News* all on the subject of smell.

(5) When the 1952 report was prepared the total population served by the Works produced a Dry Weather Flow (D.W.F.) of 4.982 million gallons per day (m.g.d.). At that time the design basis for the extensions envisaged an ultimate population of 125,000 persons resident in both the City and those parts of Chesterton Rural District which drain to the Works and on the information then available this would have resulted in a D.W.F. of 6.356 m.g.d. The present D.W.F. reaching the Works is however already 6.40 m.g.d. although the total population served is estimated to be only 110,000 persons.

(6) This marked increase in the D.W.F. is attributable to the greater use of water for domestic purposes resulting in part from improved housing conditions where families for the first time have the benefits of fixed baths and wash basins. Furthermore, various labour saving devices used in the house, e.g. washing machines and waste disposal units fitted to sinks to name but two, all contribute to this increase.

(7) The greater consumption of water per head of population has not resulted in a diluted sewage of less strength and this no doubt is due to the changing habits of people. It is however evident that a fresh appraisal must be made of the problem and in view of the present trends this will result in further extensions being required at the Works. In this report the extensions necessitated by this factor are referred to as Stage IV proposals.

(8) In July 1954 the River Board gave consent for final effluent to be discharged into the River Cam provided such effluent satisfied the standards recommended by the "Royal Commission on Sewage Disposal" and the volume did not exceed 21.7 m.g.d. These standards, drawn up at the beginning of the century require the total suspended solids present in the effluent not to exceed 30 parts per million (p.p.m.) and the Biochemical Oxygen Demand (B.O.D.) not to exceed 20 p.p.m. When making these recommendations the Royal Commission considered them to be suitable if the dilution factor based upon the volumetric ratio of effluent to river water was not less than 1 to 8. This was to ensure that natural purification could take place within a reasonable time without detriment to the biological condition of the river.

(9) From surveys of the River Cam undertaken by the River Board the existing average summer dilution factor at the point of discharge from the works is as low as 1 to 1.7 and any increase in the volume of effluent will reduce this still further. While every effort is being made to prevent any reduction in the natural flow of the river, the Board, quite properly, are asking for the standard of effluent to be improved so that neither the total suspended solids nor the B.O.D. exceed 10 p.p.m. since the new design flows are likely to produce during the summer months a dilution factor of less than 1 to 1.

(10) The most satisfactory method of producing an effluent to achieve these more stringent standards is to adopt a further treatment process and this forms Stage V of the extensions.

(11) Appendix IV to this report illustrates the analytical relationship of the total suspended solids and B.O.D. for crude sewage with those obtaining in the final effluent at present being discharged together with the current and proposed standards required by the River Board.

DESIGN DRY WEATHER FLOW

(12) In general terms the D.W.F. is directly proportional to the average volume of water used by each person and the population served by the Works. In addition allowances have to be made for trade wastes resulting from manufacturing processes and the volume of ground water which infiltrates into the sewers and drains through defective joints.

(13) Infiltration occurs mainly in the older sewers because of deterioration of the jointing material and in dry weather the volume of water is reasonably constant at about 0.965 m.g.d.

(14) Certain industrial undertakings and some residential establishments use water abstracted from their own wells. The estimated maximum pumping capacity for all these supplies is 1.35 m.g.d. but the average daily quantity is one third of this volume i.e. 0.45 m.g.d.

(15) It is not practicable to calculate the separate volumes of mains water used for domestic and trade purposes although from the total amount of such water used an estimate can be made for the combined volume per head of population. The design basis for the 1952 proposals envisaged an ultimate combined volume of 38.5 gallons per person (g.p.p.) for the City while for the Chesterton Rural District a figure of 30 g.p.p. was used plus the known discharges from Girton Laundry and Chivers Factory. A volumetric analysis of the present D.W.F. indicates that already the domestic plus trade volume from mains supply is in the order of 44 g.p.p. and consequently it is expected that this will rise to at least 50 g.p.p. over the next twenty years. Accordingly this higher value has been adopted for the new design.

(16) The design of Stages III, IV and V has been based on the estimated flow from 112,000 persons (resident and student) in the City and 23,500 persons in the parts of Chesterton Rural District which drain to the Works—a total of 135,500 persons.

These figures are based on the asumption that

(a) the resident population of the City will increase from ...	88,842 to	100,000
(b) the student population in the City will increase from ...	9,548 to	12,000
(c) the population in the parts of Chesterton Rural District will increase from	11,980 to	23,500
Total population to be served by the Works will increase from	110,370 to	135,500

(17) This represents an overall increase in population in the whole drainage area of 25,130 persons which is equivalent to an increase of approximately 22½%.

(18) Whilst there must always be some degree of uncertainty in forecasting future population—and this is particularly so in view of the discussions now taking place regarding the planning of Cambridge and the villages immediately outside the City boundary—the figures quoted above are the best estimation that can be made.

(19) However, should the population in the drainage area increase beyond the estimate of 135,500 persons, the design would permit further extensions to be added to the Works when necessary.

(20) The Design Dry Weather Flow is therefore made up in the following manner:—

135,500 persons at 50 g.p.p.	6.775 m.g.d.
Private supplies from wells	0.450 m.g.d.
Girton Laundry	0.016 m.g.d.
Chivers Factory	0.300 m.g.d.
Infiltration	0.965 m.g.d.
Design D.W.F.	8.506 m.g.d.

MAXIMUM RATE OF FLOW TO WORKS

(21) To ensure that a satisfactory effluent is produced at all times it is necessary to determine the maximum rate of flow at which the sewage will arrive at the Works. It will be appreciated that the D.W.F. is the calculated daily volume of crude sewage produced during a period of dry weather. There is however, a marked difference between individual hourly rates of flow experienced over any period of 24 hours.

(22) The accepted basis of design is to give full treatment for all flows up to a maximum equivalent to three times the D.W.F. Flows above this value are only given partial treatment and this is undertaken at the pumping station where separation of the excess flow—usually experienced in wet weather—takes place.

(23) At the new Pumping Station at Riverside four pumps (plus one to act as standby) have been provided to deal with the dry weather flow. These pumps will deliver into the existing twin 24 inch diameter cast-iron rising mains and discharge at the inlet to the Works. When the four pumps are operating together the total discharge will be at the rate of 16.70 m.g.d. and is equivalent to a D.W.F. of 5.57 m.g.d. which is in excess of that at present reaching the station.

(24) It is however expected that the new pumping station will eventually serve 107,000 persons and have to deal with a maximum flow at the rate of 20.295 m.g.d. In the ordinary course of events these conditions will not arise for a number of years. Consequently great care has been taken when selecting the D.W.F. pumps to ensure that the characteristic curves indicate efficient operation over the anticipated range. When the flow to the pumping station approaches the lower limit, i.e. at the rate of 16.70 m.g.d., it will be necessary to provide additional rising main capacity and so reduce the friction head against which the pumps are delivering thus increasing the pumping capacity to the required upper limit of 20.295 m.g.d.

(25) In the case of the smaller Pumping Stations discharging direct to the Works and where no separation of excess flow is practicable the maximum rate of flow depends upon the type of sewerage system serving the area. If a percentage of surface water is admitted to the foul sewers, i.e. a partially separate system the maximum pumping rate is six times the D.W.F. and this is reduced to four times when a separate system is in use.

(26) The maximum rate of flow to the inlet at the Works for the design period is therefore equivalent to

(i) From the main pumping station:			
Mains water supply	107,000 × 50 × 3	=	16.050 m.g.d.
Private wells supply	0.450 × 3	=	1.350 m.g.d.
Infiltration	0.965 × 3	=	2.895 m.g.d.
			20.295 m.g.d.

(ii) From other pumping stations:			
Mains water supply	15,000 × 50 × 4	=	3.000 m.g.d.
Ditto	13,500 × 50 × 6	=	4.050 m.g.d.
Girton Laundry (controlled by Agreement) ...	... ...	=	0.016 m.g.d.
Chivers Factory (subject to negotiations) ...	... ...	=	0.900 m.g.d.
			7.966 m.g.d.

(27) In addition to the above the various liquids separated during treatment of the sewage will be returned to the inlet for subsequent treatment. This return flow will be pumped back at a maximum rate equivalent to 2.739 m.g.d.

(28) The maximum design rate of flow for treatment is therefore equal to

$$20.295 + 7.966 + 2.739 = 31.0 \text{ m.g.d.}$$

and this value has been adopted for Stages III, IV and V of the proposed extensions.

DESCRIPTION OF STAGE III EXTENSIONS

INTRODUCTION

(29) The drying qualities of the raw sludge, even when mixed with aluminium chlorohydrate as a conditioner only permits approximately 45% of the sludge yield to be dealt with on drying beds. The remaining quantity is passed to shallow lagoons on arable farmland, and over the past years the area available for farming has been decreasing owing to the extra land required to handle the wet sludge.

(30) Complaints are still received, particularly from the area to the South West of the Works, about the smell nuisance. The smell arises mainly from the large areas where raw sludge is drying and is particularly potent in hot humid weather. The nuisance has been reduced to a large extent by spraying "Alamask" into the air to counteract the smell when prevailing winds are towards the more compact residential areas, but running costs would be prohibitive if this spray was used for prolonged periods. Housing development is now proceeding in the Milton area to the North East of the Works and it is probable that further complaints about the smell will be made by the future residents.

SLUDGE TREATMENT AND POWER GENERATION

(31) It is therefore essential that digestion should be introduced in order to facilitate the disposal of the sludge. In addition to the reduction in volume of the sludge the process will result in the elimination of smell nuisance, and the improvement of the drying properties. At the same time the methane gas produced in the heated digestion process will be available for use in dual fuel engines coupled to generators for the production of electrical power to be used on the Sewage Works and at the Riverside Pumping Station.

(32) The site for the proposed Sludge Treatment Plant and Power House has been changed from that originally put forward in 1952 to an area of land to the South East of the bacteria bed site and is shown on drawing numbered C/3914/8/1 forming part of this Report (and to a larger scale on drawings numbered B/3914/13/2, B/3914/6/1 and B/3914/7/1). This new site allows for the proposed extensions of the bacteria beds to be adjacent to the existing beds, and will permit future extensions to be carried out to the sludge treatment plant when occasion arises, without interfering with other operational plant.

(33) Due to the essential resiting of the Power House it becomes necessary to build a separate Administration Building near to the Works Entrance and main road in place of the combined building originally proposed. This has the advantage of eliminating the problem of the noise of the generators, which would be transmitted through the structure of a combined building, affecting the offices and laboratory.

SLUDGE PRODUCTION

(34) It is estimated that at the design dry weather flow, approximately 61,000 gallons of raw sludge, with a moisture content of 96% will be drawn from the sludge hoppers of the Sedimentation Tanks each day for treatment. This figure is based on the present average suspended solids in the sewage at the inlet chamber and on an overall tank settling efficiency of 65%.

SLUDGE DEWATERING TANKS

(35) To make full use of the available capacity of the proposed primary sludge digestion tanks it will be necessary to reduce the moisture content of the raw sludge from 96% to approximately 94%. At this reduced moisture content the sludge is still sufficiently fluid to be pumped but not too watery to unnecessarily occupy tank capacity.

(36) This thickening of the raw sludge can be achieved by quiescent settlement for a period of twenty four hours. The reduction in moisture content of the sludge from 96% to 94% is equivalent to reducing the volume of sludge to be handled by one third.

(37) To obtain this reduction in volume four 20 feet square tanks will be constructed with 10 feet side wall depth and 45° pyramidal hopper bottoms, which will provide the necessary capacity and facility of operation. Provision will be made for drawing off the topwater separated out during the settlement period and returning it to the works inlet chamber.

(38) An 18 inch diameter gravity main will connect the Sedimentation Tank desludging chambers to a raw sludge well at the Power House where pumping plant will be used to raise the sludge into the Dewatering Tanks.

PRIMARY SLUDGE DIGESTION TANKS

(39) The design of this plant has been based on the results obtained from experimental work carried out at the sewage works with a 140 cu. ft. capacity pilot unit.

(40) Two circular primary sludge digestion tanks are to be constructed with conical hopper floors, of 205,000 cubic feet capacity equivalent to 1.5 cu. ft. per head of population. Each tank will have a floating roof gas collector providing a total capacity of approximately 40,000 cubic feet of gas storage. From the pilot plant it is estimated that gas yield will be of the order of 0.8 cu. ft. of gas per person per day. The tanks and their ancillary plant will be designed so that the sludge can be maintained at the optimum temperature of 91°F.

(41) Hot water for heating and maintaining the sludge at this temperature will be provided by the engine cooling water system. Heating the contents of the tanks together with the daily sludge feed and intimate mixing of the tank contents to prevent scum formation will be carried out with equipment that operates on the air lift principle using sludge gas and has the advantage over other methods that it can be fixed external to the tanks. At the same time it has no working parts in contact with sludge, no pipework or machinery is inside the tank. The gas blowers can be housed at any convenient place and the whole installation is therefore available for easy and regular maintenance.

(42) Raw sludge, after dewatering, will be fed to the tanks at a slow and controlled rate by positive displacement pumps to assist in maintaining constant tank temperatures and even rates of gas production. Spent sludge will be hydraulically displaced from the base of the tank floor and gravitate, or be pumped from the digested sludge well, to the Secondary Digestion Tanks.

(43) Provision will be made in the plant pipework arrangement to enable the two tanks to be operated in series or in parallel.

SLUDGE GAS STORAGE CAPACITY

(44) The proposed floating gas collector roofs, to the Primary Sludge Digestion Tanks, will provide a storage capacity of approximately 40,000 cu. ft., equivalent to 9 hours gas production at a uniform rate. It is estimated that sufficient electricity can be generated from this gas each day for the normal running of the Works plus one "dry weather flow" pump at the Main Pumping Station. As sludge gas may not be produced at a uniform rate and since electrical power demand will not be constant (being dependent on sewage flows) the gas storage capacity is made equivalent to the demand of one engine running on full load for nine hours. The storage capacity will therefore avoid waste of gas produced at times of low power consumption and provide extra gas to meet high power demands.

SECONDARY SLUDGE DIGESTION TANKS

(45) The function of the secondary digestion tanks is to provide quiescent conditions in which the hot spent sludge can cool and at the same time permit the alkaline liquids and the denser sludges to separate. The alkaline waters will be drawn off and returned via the Power House Well to the Inlet Chamber for further treatment, and the denser sludge passed to further drying processes.

(46) The system of digestion involves little likelihood of serious breakdown, but should it become necessary to empty a primary digestion tank then in an emergency temporary capacity for the contents could be made available in the secondary digestion tanks. Provision will be made to return such contents to the primary tank if operationally desired so ensuring a minimum period of reduced gas production.

(47) Two rectangular flat bottomed tanks are to be constructed each 120 feet long by 50 feet wide with an average side wall depth of 8 feet, providing a total capacity of 100,000 cu. ft. or 0.75 cubic feet per head of population. This capacity will provide about 15 days retention of the daily sludge yield, any longer period being unnecessary as it is proposed to deal with the daily yield by a mechanical sludge drying plant.

(48) This period of storage also allows the daily operation of the primary digestion tanks and sludge drying process to be carried out independently of each other and for each unit to be run at its greatest efficiency.

SLUDGE DRYING BEDS AND PLANT

(49) At the time of preparing the 1952 Report it was envisaged that it would be necessary to supplement the area of sludge drying beds by the use of lagoons on the old land treatment area until such time as sludge digestion was adopted. It was anticipated that the reduction in volume of sludge resulting from the digestion process would permit all the sludge to be dried on the beds. Due to financial restrictions obtaining at the time the Stage I extensions were implemented only three quarters of the calculated area for the drying beds was constructed. It has subsequently been found that only 45% of the present sludge yield can be treated on the drying beds due to climatic conditions preventing the sludge from drying out quickly enough even with aluminium chlorodhydrate added as a conditioner. Calculations for the future sewage flow indicate that the quantity of digested sludge to be dried will be approximately 28,000 gallons per day which is comparable to the quantity of raw sludge produced at present.

(50) It is therefore necessary for the capacity of the sludge drying plant to be increased. A mechanical plant of the filter press type capable of dealing with the daily yield of digested sludge, is proposed rather than doubling the area of drying beds.

(51) A filter press is made up of a series of cast-iron plates with coarse filter cloths of jute or similar material between them and when the plates are closed tightly together they form a series of cells. The sludge is pumped between the filter cloths at a pressure of about 100 lb./sq. in. which allows the solid particles to be retained by the cloths and the liquid portion to pass through and drain away. The filtrate is then returned to the works inlet chamber for treatment. On releasing the induced pressure on the press, the plates can easily be pulled apart allowing the "sludge cake" to fall out on to a conveyor or into a vehicle for subsequent disposal.

(52) To obtain the optimum filtration characteristics for the sludge it will be necessary for conditioners to be added before pressing. The most common reagents are lime and copperas (ferrous sulphate) added at a dosage of 20% lime and 10% copperas by weight on a dry solids basis. At these dosage rates the treatment compares favourably with alternative methods of drying sludge from both the practical and economical basis. Storage facilities for these materials and suitable mixing tanks have been included in the proposed Works.

(53) This type of plant is capable of treating the digested sludge independently of the vagaries of the English climate and would remove any risk of smell and vermin nuisance which would otherwise arise if the sludge was dewatered on the drying beds. In addition it will free at least 25 acres of farmland at present occupied by sludge lagoons and can be installed on the site of three of the existing drying beds. The remaining beds would be retained and used in a standby capacity or in an emergency.

(54) The press-dried sludge with a moisture content of approximately 60% compared with 70% for sludge from the drying beds would be a much more acceptable material for farmers to whom it could be sold at a nominal charge. The 10% reduction in moisture content represents approximately 25% reduction in weight of dried sludge to be handled, i.e. 6,500 tons compared to 8,700 tons per year.

(55) Difficulties are experienced from time to time in disposing of the sludge and an area of land will be set aside for stacking purposes to meet these occasions.

SLUDGE PUMPING PLANT

(56) The sludge pumping plant will be housed in part of the power house building. Horizontal centrifugal open impeller type pumps will be used for handling the liquors and sludges of high moisture content, and positive displacement type pumps for handling the lower moisture content sludges.

POWER GENERATING PLANT

(57) The result of investigations into the alternative systems for supplying electrical power to the Sewage Treatment Works and the Riverside Pumping Station were stated in the report of 1952 and more recently in the report to the Public Works Committee in January 1962. The scheme approved was to provide generating plant driven by dual fuel engines to supply the full electrical power requirements of the Sewage Works, and sufficient power at the new Main Pumping Station at Riverside to operate the ancillary equipment and the four "dry weather flow" pumps. Four dual fuel engines and generating plant each of 460 kW capacity are to be installed, three providing the maximum power demand and one acting as standby. The estimated maximum load demand from all sewage works and pumping station plant is 1,375 kW. Electrical power will be generated at 415 volt, 3 phase, 50 cycles and a step up and step down transformer will be provided at each end of the suitably rated 11 KV High Tension underground feeder cable to the Riverside Pumping Station (the proposed route is shown on drawing number B/3914/15/1).

(58) It is essential for the most economic running of the pumping plant at the Pumping Station that the construction of the Power House and associated Sludge Digestion Plant be proceeded with as soon as possible. Until the source of electrical power is available from the Sewage Works a supply is provided by the Eastern Electricity Board that is insufficient to run both "Dry Weather Flow" and "Storm Flow" Pumps should occasion arise.

(59) When the Sludge Digestion Plant is in operation a daily quantity of at least 100,000 cubic feet of gas will be available at a net calorific value of 650 B.Th.U's per cubic foot, which is equivalent to a continuous supply of some 300 kW. This will be sufficient for normal running loads and when additional power is required this will be provided by burning fuel oil or varying the mixtures of gas and fuel oil, in the engines.

(60) The thermal efficiency of the engines will be increased by using exhaust gas boilers, the hot water from the engine cooling circuit being used in plate to plate type heat exchangers to maintain the operating temperature of the sludge digestion tanks. At times of low power demand, particularly in cold weather, sufficient heat may not be available from the engines to maintain tank temperatures. In these circumstances electrode boilers will be brought into service to maintain the tank temperature.

(61) A medium pressure effluent main will be provided round the Works to supply secondary cooling water for the lubricating oil coolers and heat exchangers at the Power House. In addition it will supply water for the maintenance staff when cleaning and washing down the various tanks and channels of the treatment units.

POWER HOUSE BUILDING

(62) A building will be necessary to accommodate the engines, generators, switch gear, etc., and will also house the sludge treatment pumping plant, works control board, stores and workshop for general maintenance.

(63) It is proposed to construct the Power House building in reinforced concrete, the superstructure consisting of a concrete framework with infill panels.

(64) The layout of the type of plant it is proposed to instal is shown, with sections on drawing numbers B/3914/8/1, B/3914/9/1 and B/3914/10/1.

ADMINISTRATION BUILDING

(65) The extension of the Sewage Works as proposed in this report will necessitate the employment of more maintenance staff including a number of highly skilled and semi-skilled men with knowledge of mechanical and electrical plant. In order to ensure efficient operation and to attract the right type of personnel the present administration and domestic arrangements will have to be improved.

(66) It is therefore proposed to construct an Administration Block close to the Works Entrance to provide under one roof suitable sized office accommodation, laboratory, store, first aid room and messing and changing room facilities for the works staff.

HOUSING

(67) Due to the increasing mechanical complexity of the sewage treatment equipment it will be necessary for efficient works operation to have highly specialized staff readily available at the works.

(68) It is proposed to build a further three houses on the works site, for the use of this technical staff.

DESCRIPTION OF STAGE IV EXTENSIONS

INTRODUCTION

(69) The arrangement of the proposed extensions are shown on drawing number C/3914/8/1 forming part of this report, and to a larger scale on drawings numbers B/3914/13/2, B/3914/3/1, B/3914/4/1 and B/3914/5/1.

(70) The major portion of the sewage flow to the Works comes from the Main Pumping Station where screens are provided to remove the larger solids which would otherwise damage the pumps. The remaining portion arrives from the small pumping stations and at these some maceration of the solids present in the sewage takes place. It has not been found necessary, by past experience to provide screens at the Works and no such provision is made in these extensions.

(71) The existing Dorr-Detritor at the inlet to the Works removes and washes the grit from the sewage and is designed to treat a maximum flow of 25 m.g.d. but the proposed design maximum flow through this unit will be 31 m.g.d. at peak periods. At this rate some of the finer and lighter grit may be carried through to the Sedimentation Tanks where it will settle out although in view of the limited number of occasions when this situation will arise it is not considered necessary to increase the provision for grit removal at this stage. If difficulty is experienced in the future the problem can be overcome by modifying, or if circumstances demand duplicating the existing Detritor.

SEDIMENTATION TANKS

(72) The present Sedimentation Tanks are operated in parallel from a long transverse supply channel, which is fed at one end from the measuring flume channel. This arrangement was dictated by the channels of the original sedimentation tanks and adopted because of the financial restrictions at the time of the previous extensions. The distribution of the sewage to the tanks by this arrangement leaves much to be desired and would be made even worse by any extension of the channel to feed the two further tanks.

(73) It is therefore proposed to feed the extended channel at two points, and make provision for a third entry point for future extensions. Owing to lack of space and available hydraulic head between the Detritor and the Sedimentation Tanks it will be necessary to replace the present measuring flume channel with new ones for each point of entry.

(74) The existing Sedimentation Tanks have proved satisfactory in operation and it is therefore proposed to construct two similar shaped tanks to maintain the required period of retention. With the proposed modifications to the feed arrangements it will be possible to improve the tank efficiency.

(75) The arrangement of the existing tank pipework does not permit individual sludge hoppers to be emptied, nor is it possible to easily empty a tank for maintenance. The present use of a portable pump for these purposes involves a tank being non-operational for about 36 hours for emptying alone. It is proposed to modify the pipework by the insertion of a number of valves to enable desludging individual hoppers to be carried out, and for a tank to be easily emptied.

(76) It is also proposed to dispense with the present overflow weir in the Sedimentation Tanks collecting channel, together with the open feed channels used in connection with land treatment, and this will enable all flows to be passed forward for complete treatment. This will free some 9 acres of land for farming, at present kept for treating rates of flow in excess of 19 m.g.d.

BACTERIA BEDS

(77) The existing Bacteria Beds are operating on a system involving the recirculation of effluent from the Humus Tanks and this has proved most effective in treating the Cambridge sewage. A satisfactory effluent to present day standards has been produced since their construction, even during the severe winter of 1962/63, and it is therefore proposed to continue this form of treatment at the same dosage rate of 120 gallons per cubic yard of media calculated on the design D.W.F.

(78) Due to financial restrictions at the time of the previous extensions the extra half bed required by the design was not constructed and this has involved overloading the beds when one is out of operation for maintenance purposes.

(79) It is therefore proposed to construct two new beds, including a new mixing and distribution chamber complete with modifications to the effluent recirculation main to serve the new beds, plus a new collecting channel and the reconstruction of the existing distribution chamber serving the humus tanks.

(80) The proposed site for the new beds is on land to the South West of the existing ones so maintaining a compact unit with corresponding simplification of feed and discharge arrangements. This site involves the demolition of the existing earth banked tanks which occupy part of the area.

(81) The site to the North East of the existing beds will be reserved for a future single bed and provision is in existence for supply to and discharge from this bed. The remaining part of this northern site is reserved for the Northern By-pass Road for Cambridge.

EFFLUENT RECIRCULATION

(82) It is not intended to alter or amend the two existing variable speed pumps as these will be capable of maintaining a flow of between 2 to $2\frac{1}{2}$ times the design D.W.F. to the bacteria beds. It will however be necessary to provide a connection to the new bacteria bed distribution chamber, and modifications will be required to the method of remote control of the recirculation pumps.

(83) It is proposed to house the medium pressure wash water pumps and pressure vessel in an extension to the existing building.

HUMUS TANKS

(84) Four new circular humus tanks are required similar to those constructed as part of the previous extensions. These tanks are 65 feet in diameter and have a side wall depth of 6 ft. 9 in. with a 10° sloping conical floor.

(85) The fine sludge present in the liquid from the bacteria beds settles to the floor of the Tank where it is mechanically swept to a central hopper. From here it is drawn off to the existing humus sludge pumping station and returned to the works inlet for treatment.

(86) The construction of these new tanks will provide a 5 hour period of retention for that proportion of the design dry weather flow in the circular tanks and at the same time ensure that the upward flow velocity does not exceed 8 feet per hour in the older rectangular pyramidal tanks dealing with the remainder.

(87) In addition a tank emptying main from the new and existing circular tanks will be provided to enable routine maintenance to be carried out easily and to reduce the period of time any tank is out of commission.

DESCRIPTION OF STAGE V EXTENSIONS

INTRODUCTION

(88) To enable as much as possible of the very finely divided solid matter present in the bacteria bed effluent to be removed before the final effluent is discharged to the river the humus tank capacity is being increased as part of the Stage IV extensions. It is however not practicable to produce a final effluent which will satisfy the revised requirements of the River Board by this means alone and consequently an additional treatment process will have to be adopted.

(89) A thorough investigation has been undertaken into the most suitable process to adopt for this further treatment of the effluent and because of the large area of land available at the Works consideration was given to either a system of grass-land treatment or to treatment in shallow lagoons. The result of these investigations led to the conclusion that neither of these methods could be guaranteed to produce the standard of effluent required for the large quantity of effluent and at the same time be free from smell nuisance.

(90) A new development know as the "Banks Clarifier" has also been investigated but this was found to be impracticable for the design dry weather flow of the Works.

(91) It appears therefore that the most suitable and practical form of tertiary treatment, capable of producing an effluent to the higher standard now required, would be to pass the flow from the humus tanks through either microstrainers or rapid flow sand filters. The cost of such plant required for this form of treatment has been included in the estimate of cost for the extensions.

(92) Further investigation is however necessary to determine which of these methods will provide the most suitable and economic solution to the particular problem of the Cambridge sewage. Three firms are prepared to loan the City Council experimental plant for the purpose of the necessary determination and it is proposed to report more fully on this work at a future date.

EFFLUENT OUTFALL

(93) The effluent from the existing Humus Tanks is discharged by gravity to the River Cam above Baits Bite Lock through a 42 in. diameter concrete pipe. When maximum flow conditions of 25 m.g.d. obtain and the river is in flood, an old 24 in. diameter concrete pipe discharging below Baits Bite Lock is also brought into use.

(94) To cater for the new maximum design flow of 31 m.g.d. and to make provision for future extensions it is now necessary to duplicate the existing 42 in. diameter pipe and at the same time modify the existing outfall so that both pipes discharge at one point. This arrangement will enable the old 24 in. diameter main laid in 1914 to be discontinued for sewage effluent discharge and retained solely for land drainage purposes.

GENERAL

SITE WORKS

(95) The clearance of the site prior to the extensions being undertaken will involve demolition of the old surface sludge channels and buildings, and it is intended that the whole area will be landscaped on completion of the works. In addition the construction of new concrete roads and footpaths, complete with surface water drainage, will be necessary to provide vehicular and pedestrian access to the various units of plant.

(96) New distribution cables will be required for the electricity supply to power driven mechanical plant included in the extensions. These cables will also supply an extension to the existing system of lighting around the Works together with extra flood lighting at strategic points so that maintenance can be carried out during hours of darkness in an emergency.

STAFF AND RUNNING COSTS

(97) The necessary increase in the size of the Works and the greater use made of mechanical plant will demand the employment of suitably qualified technical staff. A proposed establishment with salaries is given below.

Position	*Salary*	*Grade*	*Total (Max.)*
1 Manager	£1,610—£1,940	Scale B	1,940
1 Plant Superintendent	£1,290—£1,555	A.P.T. IV	1,555
1 Chemist	£1,090—£1,340	A.P.T. III	1,340
1 Lab. Assistant	£295— £590	Gen. Div.	590
1 Clerk/Typist	£295— £590	Gen. Div.	590
1 Works and Maintenance Foreman	£930—£1,050	Misc. VII	1,050
Shift Workers			
4 Shift Engineers	£900	Eng. Crafts+	3,600
4 Switchroom Attendants	£650	Semi-skilled 4+	2,600
4 Engine Room Attendants	£650	”	2,600
4 Filter Plant Attendants	£650	”	2,600
Day Workers			
5 Plant Attendants	£620	Manual VI	3,100
6 Labourers	£600	” III	~~3,000~~ 3,600
Maintenance Workers			
1 Electrician	£775	Eng. Crafts+	775
1 Fitter	£775	”	775
2 Craftsmen's Mates	£650	Semi-skilled 4	1,300
			~~£27,415~~ 28,015

The proposed total labour force at the Sewage Works to be 37. The present maintenance staff of 14 at the works costs approximately £8,000 per year.

(98) It is estimated that the cost of running the works excluding loan charges and staff costs will be of the order of £27,000 per year. (Present running costs approximately £10,000 per year). This sum includes for all the plant covered in this report as Stages III, IV and V.

(99) The present and proposed staff and running costs are not directly comparable for the following reasons:

(i) The conditions at the Sewage Works will be completely altered from that pertaining at present by the production of a higher effluent standard from a greater sewage flow and by the generation of electrical power.

(ii) There will be a reduction in staff due to the closure of the existing Cheddars Lane Pumping Station on the completion of the new semi-automatic Riverside Pumping Station.

ESTIMATE OF COSTS FOR STAGES III, IV AND V

(100) Item	Construction £	Machinery £	Total £
a. Modification to Flume Channel and Sedimentation Tank Feed	18,450	750	19,200
b. Additional Sedimentation Tanks and Modification to Existing	33,000	14,000	47,000
c. Additional Bacteria Beds	188,500	32,000	220,500
d. Additional Humus Tanks	40,500	7,000	47,500
e. Modifications to Recirculation Pumps Controls and Additional Medium Pressure Wash Water and Secondary Engine Cooling Water Main	7,000	2,000	9,000
f. Power House and Sludge Pumping Station including Feeder Cable to Riverside Pumping Station	73,000	117,000	190,000
g. Dewatering tanks	22,000	—	22,000
h. Primary Sludge Digestion Tanks	42,000	45,000	87,000
i. Secondary Sludge Digestion Tanks	17,500	3,500	21,000
j. Sludge Dewatering Plant	21,500	63,000	84,000
k. Tertiary Effluent Plant, including Wash Water and Final Effluent Mains	170,000	80,000	250,000
l. Administration and Laboratory Building (Including Equipment and Furnishing) ...	12,000	—	12,000
m. Staff Housing	9,000	—	9,000
n. Site Works, etc.	8,000	—	8,000
o. Electric Cables, Wiring, Lighting, etc., on Works	12,000	—	12,000
p. Contingencies	—	—	56,300
q. Clerk of Works—Fees, etc.	—	—	22,000
r. Easements	—	—	3,000
			£1,120,000

The above items include for all necessary gravity and rising mains connecting the units.

SUMMARY OF COSTS

(101)		
	Stage III (Sludge Treatment and Power House)	£450,000
	Stage IV (Extensions of Sewage Treatment Plant and Final Effluent Main) ...	£420,000
	Stage V (Tertiary Unit)	£250,000
		£1,120,000

APPORTIONMENT OF COSTS

(102) Existing Agreements with the Chesterton Rural District Council and Chivers-Hartley Ltd. provide for reimbursement to the City Council of a proportion of the capital costs involved in the construction of the extensions included in Stages I, II and III, and for payment to the City Council for costs in treating sewage flows received. It will however be necessary to revise the existing Agreements to allow for the increasing sewage flows and additional costs of treatment plus a proportion of the capital costs involved in Stages IV and V.

TECHNICAL SUMMARY

(103) The data sheets forming Appendix V to this Report provide a technical summary of the main units required for the extensions and the flow diagram (Appendix VI) indicates how the completed works will function.

RECOMMENDATIONS

(104) It is suggested that the Public Works Committee should recommend to the City Council:

1. That the extensions to the Cambridge Sewage Works described as Stages III and IV of this Report be approved, and subject to the necessary approvals of the Ministry of Housing and Local Government being obtained, authorise the preparation of the contract drawings and documents and the invitation of tenders.

2. That as approval in principle was obtained from the Ministry of Housing and Local Government for sludge treatment and power generation at the time of the 1952 Report, and to expedite the preparation of detail drawings for Stage III of the proposed extensions, authority be given for the invitation of tenders from specialist machinery manufacturers.

3. That negotiations be entered into with the Chesterton Rural District Council and Chivers-Hartley Ltd., with a view to terminating the present Agreements, as to the reception and disposal of sewage, and arranging new Agreements having regard to the cost of the proposed Works extensions and the increasing cost of treatment.

4. That Stage V of the proposed extensions be approved in principle and authority be given for further investigations to be continued at the Works to establish the most suitable type of tertiary treatment plant.

APPENDIX I

Brief history of the Cambridge Sewage Works including a description of the method of operation.

HISTORY

A Works was first constructed at Milton Road in 1895, when lime mixing tanks (later adapted as grit tanks) were built, and part of the site provided with underdrainage for land treatment with an effluent pipe discharging into the River Cam below Baits Bite Lock. Early difficulties in the satisfactory purification of the sewage led to the construction of the first sedimentation tank in 1906 together with underdrained sludge drying beds.

Between 1913 and 1915, the effluent pipe was duplicated, five secondary sedimentation tanks were added and the capacity of the primary tank increased. This was followed in 1917 by the area used for land treatment being extended by 62 acres. During 1925 a sludge pump, still in service, was added to enable the five secondary sedimentation tanks to be desludged more easily, and modifications were made to the tanks themselves.

In 1929 the effluent was showing signs of having a very bad effect on the River Cam and in 1933 experiments were carried out with a small bacteria bed and this was found to treat the settled sewage successfully. In view of the extensions to the Borough boundary in 1934 and the continued deterioration in the quality of the effluent from the land treatment process, it was decided in 1937 to construct bacteria beds together with humus tanks and a humus pump house. In addition the capacity of the sedimentation tanks were increased by raising the tank walls. These extensions enabled a dry weather flow of 3.6 m.g.d. from a population of 72,850 to be treated. Flow rates up to 2.0 m.g.d. were treated on the bacteria beds and excess flows were passed to land treatment.

The continuing rise in population over the following years coupled with financial restrictions on capital expenditure again resulted in a deterioration in the quality of effluent produced at the Works. Reports were submitted in 1948, 1950 and 1952, the latter one forming the basis of the extensions completed in 1958.

METHOD OF OPERATION

The foul sewers within the drainage area all gravitate to sewage pumping stations of which the largest is the Riverside Pumping Station at Cheddars Lane, approximately two miles from the Sewage Works. This existing pumping station is capable of delivering a maximum rate of flow to the inlet chamber of the Sewage Works of 10.4 million gallons per day through two existing 24 inch diameter rising mains. Flows in excess of this rate, such as occur in wet weather, are pumped to Storm Water Tanks adjacent to the Pumping Station, which have a capacity equivalent to approximately six hours dry weather flow. Quantities of sewage received in excess of this amount after passing through the tanks overflow to the River Cam. After a storm flow has subsided the contents of the tanks are returned to the pumps and delivered with the sewage flow to the works inlet chamber. The new Pumping Station being built at the Riverside Site will enable a maximum rate of flow of 16.7 million gallons per day to be delivered through the existing mains to the Sewage Works.

Smaller quantities of sewage are also pumped direct to the Works from the City's Milton Road Pumping Station and three pumping stations of the Chesterton R.D.C., but at these stations no "separation" of storm water takes place.

The arrangement of the existing treatment plant at the Works is shown on drawing number C/3914/8/1 bound with this report (and to a larger scale on drawing number B/3914/13/1).

Primary Treatment, which consists of the removal of the heaviest solids in the crude sewage, is achieved at Cambridge in two stages. The first stage is a Dorr-Detritor where the inorganic grit is settled out from the crude sewage and this grit after being cleaned is used for repairing the farm tracks. In the second stage the crude sewage is passed very slowly through relatively large Sedimentation Tanks, thus enabling the greater part of the organic solids to settle to the floors of the tanks. These solids are then gently pushed along the bottom of the tanks by mechanical scraper to hoppers at the inlet ends of the tanks, and removed once a day in the form of "raw sludge". The liquid from which the solids have settled, known as "settled sewage", then passes over weirs at the ends of the tanks to the Secondary Treatment process.

Secondary Treatment is necessary to remove those impurities in either solution or the colloidal state, which cannot be removed by settlement, and this operation consists of subjecting the settled sewage to bacterial action where the oxygen from the air plays an essential part. This process is effected by trickling the settled sewage over Bacteria Beds at as constant a rate as possible, the rate being maintained by the recirculation of the final effluent to the beds. Extensive experiments carried out prior to deciding the process to be adopted as the design basis embodied in the 1952 Report indicated that this was the most suitable method for treating the sewage.

The beds are large rectangular containers, ventilated to the atmosphere at the base to permit air circulation and filled with clinker to a depth of approximately 6 feet. Bacteria colonies develop on the surface of the clinker and break down the source of pollution in the settled sewage as it trickles through the bed. During this process additional solid matter is formed by the bacteriological and ecological life in the bed and this is removed by slowly passing the bed effluent through large circular "Humus Tanks" where the fine particles of solid matter are able to fall to the tank floor. This humus sludge is mechanically scraped to a central hopper and from here it is continuously returned to the works Inlet Chamber where it is mixed with incoming crude sewage for treatment. The liquid from which the Humus has been settled passes over weirs and gravitates to the Outfall Chamber where it discharges into the River Cam just above Baits Bite Lock.

The degree of purification given by the treatment process is indicated on the Chart in Appendix IV, which shows the average monthly analyses for crude sewage and final effluent for the years 1963 and 1964. The present River Board consent to discharge final effluent to the River Cam requires a "Royal Commission" standard of 30 parts per million of suspended solids and 20 parts per million of bio-chemical oxygen demand. It will be noted that at certain periods of the year the purification does not comply with these standards.

The raw sludge drawn from the Sedimentation Tanks is pumped to the sludge drying beds, consisting of large shallow underdrained tanks, where 18 inches of wet sludge will dry to a thickness of 5 inches over periods varying from 2 months to 1 year depending on the weather and characteristics of the particular sludge. Due to the indefinite period of drying it often happens that no beds are available and in such circumstances it becomes necessary to pump large quantities of the raw sludge to shallow lagoons on the farm area.

The texture of the dried sludge is like peat and it is lifted from the bed area by a mechanical excavator and taken by dumpers to a stack for disposal as a soil conditioner on our own farm and other agricultural establishments. The lagoon areas when dried are ploughed and the land cropped.

CHARACTER OF SEWAGE

The sewage received at the Works is predominantly domestic but also contains minor quantities of various trade wastes from laundries, breweries, plating works, gas works and other industrial premises. The sewage generally is of average strength and analyses are given in Appendix III.

Agreements are to be negotiated with the various manufacturing and processing firms in the drainage area to control the quality and quantity and at the same time enable a fair charge to be made for the treatment of the industrial discharges to the sewers. It is hoped that these measures will prevent the discharge of toxic wastes as these have a serious effect on the bacteria and other organisms upon which the treatment processes depend.

APPENDIX II

Definitions of expressions.

Crude Sewage: The water-borne waste products from domestic and trade sources plus ground water and any surface water as may be admitted into the sewerage system. Approximately 0.05% is solid matter of which about two-thirds is organic e.g. proteins, fats and carbohydrates, in either suspension, solution or colloidal dispersion.

Ground Water: Infiltration or ground water is that which has leaked into the sewer from the surrounding ground.

Dry Weather Flow: This is the daily volume of sewage that may be expected in a sewer during periods of climatically dry weather, and is usually measured after a period of at least six days continuous dry weather. It closely follows the usage of mains water with due allowance for infiltration of ground water and is normally quoted in millions of gallons per day. To allow for irregularities in the rate of flow due to the variations in usage of water during the day and for any rainfall admitted to the sewer it is the present practice to require full treatment to be given to all sewage arriving at the Works at a rate of flow up to the equivalent of three times that of the dry weather flow and primary treatment only to rates of flow up to six times the dry weather flow.

"Royal Commission" standard effluent: The Royal Commission on Sewage Disposal recognised the need for some definition of a good effluent and recommended as a standard an effluent containing no more than 30 parts per million of suspended matter and not more than 20 parts per million of dissolved oxygen. This standard was generally to be applied to effluents discharging into rivers where a dilution of at least 8 volumes of river water to one of effluent, could be maintained. When this degree of dilution is not available a higher degree of purification is required.

Routine tests: Many and frequent tests are necessary to establish the degree of purification effected by each stage of a treatment plant. A few notes are given on the tests in most general use and referred to in this report.

(a) **Suspended Solids**

The sample is passed through a filter of known weight and the weight of suspended solids, that is the material retained by the filter, is expressed as the number of parts by weight per million parts by weight of the original sample.

The Cambridge sewage before purification contains an average of about 380 parts per million. The final effluent to comply with the "Royal Commission" standard should not contain more than 30 p.p.m. at its point of discharge into the river.

(b) **Bio-Chemical Oxygen Demand**

This test is essentially a measure of the oxygen taken up by the living organisms in the sample and is again expressed as parts by weight of oxygen taken up per million parts of the sample.

The Cambridge sewage before purification has an average value of about 338 parts per million. Toxic trade wastes present in the sewage will however inhibit bacterial action during the test and would depress this figure giving a misleading estimate of the polluting effect. A final effluent to comply with the "Royal Commission" standard should not contain more than 20 p.p.m. at the point of discharge.

(c) There are other tests such as pH value which is a measure of the acidity or alkalinity of the sample, Ammoniacal Nitrogen, giving particular information as to the age of the sewage and also tests for nitrate and nitrite which indicate the extent to which purification has been carried out.

APPENDIX III

City of Cambridge—Sewage Treatment Works.

CRUDE SEWAGE ANALYSIS

The following are average analyses of samples of crude sewage taken every two hours from 8 a.m. to 10 p.m. for four days a week during the years 1963 and 1964.

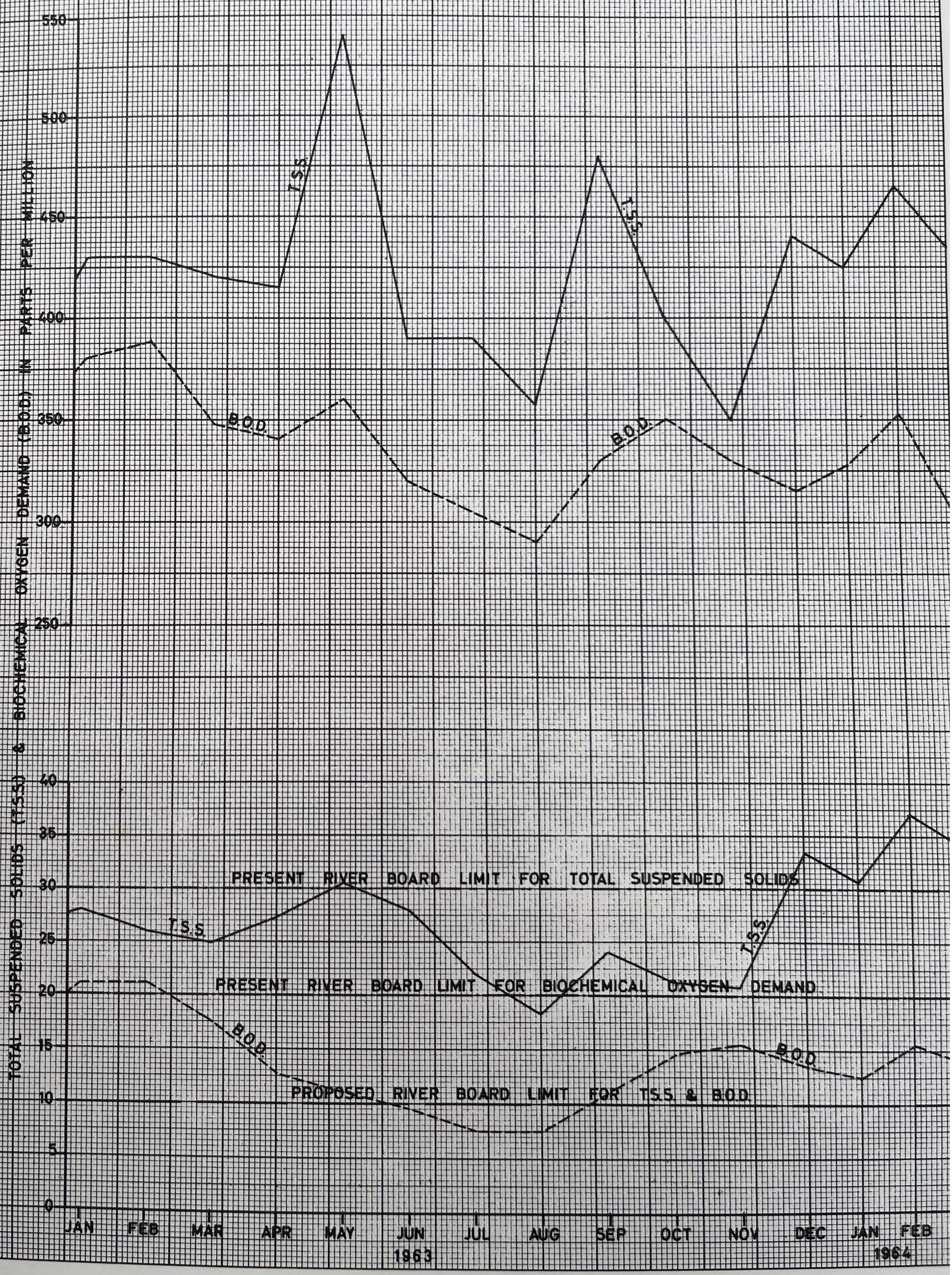
	1963	1964
Total Suspended Solids	420 p.p.m.	440 p.p.m.
Biochemical Oxygen Demand	338 p.p.m.	328 p.p.m.
Permanganate Value (4 hrs.)	96 p.p.m.	95 p.p.m.
,, ,, (3 mins.)	39 p.p.m.	38 p.p.m.
Free and Saline Ammonia	39.5 p.p.m.	34.6 p.p.m.
Albuminoid Ammonia	10.8 p.p.m.	8.2 p.p.m.

APPENDIX IV

CITY OF CAMBRIDGE SEWAGE TREATMENT WORKS

CRUDE SEWAGE & FINAL EFFLUENT

AVERAGE MONTHLY ANALYSES FOR 1963



APPENDIX V

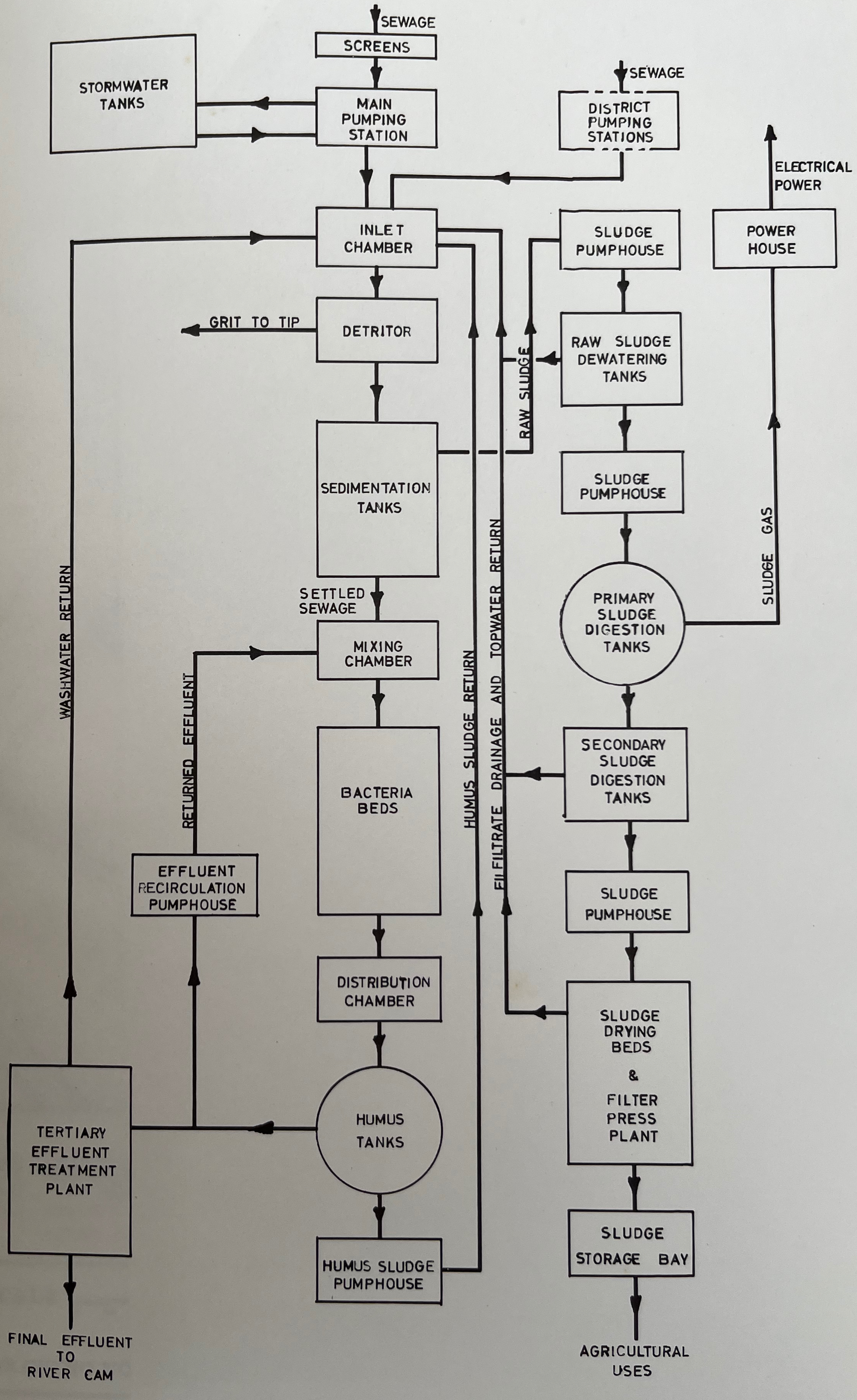
Cambridge Sewage Treatment Works—Main Units—Stages III, IV and V—Data Sheet

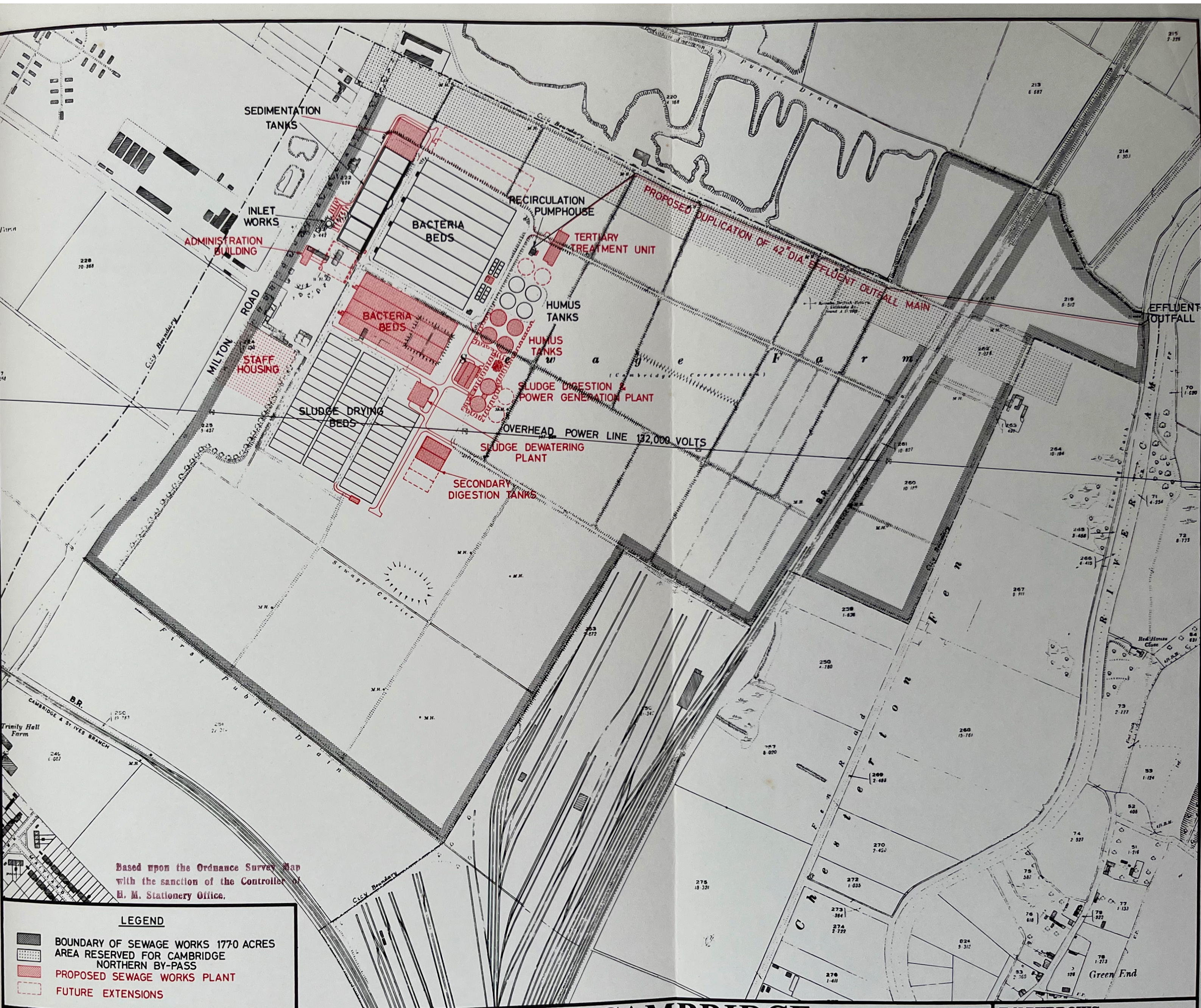
Unit	Type	Number of Units Existing	Number of Units Proposed	Total Capacity	Basis of Design	Dimensions	Remarks
PRIMARY TREATMENT UNITS							
Grit Settlement Tank	Dorr-Detritor	1	—	—	To treat maximum flow of 25 mgd at 5′ 0″ water depth	26′ 0″ diameter	Grit settled out continuously, mechanically collected, washed, and discharged to dumper for disposal.
Sedimentation Tanks	Rectangular Horizontal Flow	7	2	2,500,000 gallons	7 hours retention at D.W.F. of 8.5 mgd	125′ 6″ by 64′ 6″ wide by 5′ 6″ average depth	Mechanical Sludge Scraper and Scum removal. Modifications to existing tanks sludge withdrawal pipework, and improved flow and solid distribution to all tanks.
SECONDARY TREATMENT UNITS							
Bacteria Beds	Rectangular	4	2	73,590 cu. yd.	120 gal/cu. yd/day at D.W.F.	460′ 0″ by 120′ 0″ by 6′ 0″ average depth	Rope hauled distributors. These beds are operated on the recirculation of humus effluent system. Dosage to the beds being maintained at approximately 300 gal/cu. yd. of medium/day.
Humus Tanks	Rectangular	16	—	402,100 gallons	5 hours retention at D.W.F. 1630 gal/ft./day at D.W.F. weir loading. 8 feet per hour upward velocity at maximum flow	17′ 6″ square, 6′ 6″ deep side wall, pyramidal hopper floor	Circular tanks only provided with mechanical sludge scraper and scum removal. These tanks required to produce a settled effluent of at least "Royal Commission" standard to comply with existing consent to discharge to River Cam, and to ease loading on tertiary treatment unit when installed.
	Circular	4	4	1,424,000 gallons	5 hours retention at D.W.F. 4,400 gal/ft./day at D.W.F. weir loading. 6 ft./hour upward velocity at maximum flow	65′ 0″ diameter, 6′ 9″ deep side wall, 10° slope conical hopper floor	
Recirculation Pumping Plant	Centrifugal Vertical Spindle	2	—	8,000 gal/min each	To maintain flow on beds at rate equivalent to $2\frac{1}{2}$ D.W.F.	—	Pumping rate automatically controlled by works inlet flume. Humus tank effluent returned to Bacteria Bed Distribution Chamber.
Humus Sludge Pumping Plant	Centrifugal Vertical Spindle	3	—	1,000 gal/min each	—	—	Return humus sludge drawn from base of humus tanks to works inlet chamber, and some surface water drainage. Automatically controlled by well levels.
TERTIARY TREATMENT UNITS							
Tertiary Unit	Micro-Strainer or Rapid Gravity Sand Filter	—	—	—	To produce an effluent of at least 10 ppm suspended solids and 10 ppm biochemical oxygen demand	—	The type of unit and size and number to be decided by experimental work with pilot plant yet to be installed.

APPENDIX V (*Continued*)

Unit	Type	Number of Units Existing	Number of Units Proposed	Total Capacity	Basis of Design	Dimensions	Remarks
SLUDGE TREATMENT UNITS							
Raw Sludge Dewatering Tanks	Rectangular	—	4	21,300 cu. ft.	To provide 24 hours quiescent settlement of daily sludge output	20′ 0″ square, 12′ 0″ deep side wall, 45° slope pyramidal hopper floor	Provision made for drawing off topwater for return to full treatment, for withdrawing sludge, and for washing down tanks.
Primary Sludge Digestion Tanks	Circular, covered and heated	—	2	205,720 cu. ft.	1.5 cubic feet per head of contributing population. 0.8 cubic feet of gas per head of contributing population	62′ 0″ diameter, 32′ 6″ deep side wall, 20° slope conical hopper floor	Floating roof gas collectors for each tank total capacity 40,000 cubic feet. Provision made for feeding raw sludge, circulating tank contents, and heating tank contents to about 95°F. Automatic warning and control instruments for gas, temperature and sludge and collector levels to be provided to enable optimum conditions to be maintained.
Secondary Sludge Digestion Tanks	Rectangular and open	—	2	100,100 cu. ft.	0.75 cubic feet per head of contributing population	120′ 0″ by 50′ 0″ by 9′ 0″ average depth	Mechanical Sludge Scraper. Provide 15 days storage of daily sludge yield. Provision made for removal of topwater to primary treatment unit.
SLUDGE DRYING UNITS							
Sludge Drying Beds	Open, rectangular underdrained sand and gravel floors	42	—	29,492 sq. yd.	4½ persons per square yard	158′ 0″ by 40′ 0″ by 2′ 3″ deep side wall	These beds only handle 45% of annual sludge yield. 39 to be retained as standby for new unit.
Sludge Mechanical Drying	Sludge Filter Press	—	4	—	To handle daily yield of digested sludge	—	This unit incorporates lime and copperas stores and mixing units for conditioning sludge prior to pressing, and all necessary pumping plant and instrumentation. Will occupy site of three of the existing drying beds, and produce a more uniform and drier sludge cake than the drying beds every day irrespective of weather conditions.
Sludge Pumping Plant	Centrifugal Horizontal Spindle, Open Impeller	—	3	1,000 gal/min at 37 feet head	To handle flow of sludge from Sedimentation Tanks	—	These pumps will deliver raw sludge drawn from Sedimentation Tanks to Dewatering Tanks, deliver road and drying bed underdrainage to inlet chamber, and be capable of emptying humus tanks.
	Centrifugal Horizontal Spindle, Open Impeller	—	2	500 gal/min at 45 feet head	—	—	These pumps to deliver digested sludges to secondary digestion tanks, sludge drying units.
	Positive displacement	—	3	100 gal/min at 35 feet head	—	—	To deliver raw sludge to primary digestion tanks at positive controlled rates and to act as standby for centrifugal pumps or as forcing pumps.
Power Generating Plant	Dual Fuel Engine directly coupled to alternator and exciter	—	4	615 h.p. each	To provide full power requirements of proposed Sewage Treatment Works plant, and 'Dry Weather' pumps and ancillary equipment at Main Pumping Station	—	The engines to operate on mixtures of diesel oil and methane gas. Waste heat recovery plant to provide heating for Primary Sludge Digestion Plant. One engine acting in standby capacity. Plant includes full instrumentation and control switchgear, including Works Flow Recorders, Control and Alarm Panels providing centralised control.

CITY OF CAMBRIDGE SEWAGE TREATMENT WORKS PROPOSED SCHEMATIC FLOW DIAGRAM





SCALE 0 100 200 300 400 500 FT.

DRAWING NO C/3914/8/1

CITY OF CAMBRIDGE
SEWAGE TREATMENT WORKS EXTENSIONS
EXISTING WORKS AND PROPOSED EXTENSIONS

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CITY ENGINEER & SURVEYOR.
GUILDHALL, CAMBRIDGE.

APPENDIX VIII

Staff Associated with design of Sewage Treatment Works.

R. W. Gibb, A.M.I.C.E., A.M.I.Mun.E., A.M.I.W.E., Deputy City Engineer and Surveyor.

C. D. Cooper, A.M.I.C.E., A.M.I.Mun.E., A.M.T.P.I., Chief Assistant Engineer.

O. R. Ericsson, B.Sc., A.M.I.C.E., Principal Assistant Engineer.

H. Carter, A.M.I.Mun.E., Assistant Engineer.

J. Holding, A.M.Inst.S.P., Manager, Sewage Disposal Works.

P. Parson, Assistant Chemist.